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**COMPLETED PROJECT SUMMARY**

**TITLE:** Investigations of the Dynamics and Thermodynamics of the Mesosphere and Upper Thermosphere at the Polar Regions.

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**INCLUSIVE DATES:** 1 April 1987 - 31 March 1988

**GRANT NUMBER:** AFOSR 87-0174

**COSTS AND FY SOURCE:** \$149,482, FY87

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Dr. R. J. Sica  
Dr. G. J. Romick  
Dr. R. G. Roble

**JUNIOR RESEARCH PERSONNEL:** Mr. J. E. Schewe  
Mr. J. Conner  
Mr. A. Alcock  
Mr. J. Minnow  
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**PUBLICATIONS:**

G. Hernandez, Afocal Coupled Etalons. DEM: a high-resolution double-etalon modulator spectrometer, *Appl. Opt.*, **26**, 4857-4869 (1987).

G. Hernandez and F. G. McCormac, Afocal Coupled Etalons. Experimental confirmation of a high-resolution double-etalon modulator (DEM) spectrometer, *Appl. Opt.*, **27**, in press, (1988).

R. W. Smith, J. W. Meriwether, G. Hernandez, V. B. Wickwar and O. de la Beaujardi-

ere. Global scale studies of thermospheric dynamics in the CEDAR program. EOS, *Trans. Am. Geophys. Union*, **69**, in press, (1988).

R. J. Sica, G. Hernandez, B. A. Emery, R. G. Roble, R. W. Smith, M. H. Rees and G. J. Romick. The control of auroral zone dynamics and thermodynamics by the interplanetary magnetic field dawn-dusk (Y) component. *J. Geophys. Res.*, **93**, submitted (1988).

G. Hernandez and T. L. Killeen, Optical measurements of winds and temperatures in the upper atmosphere. Chapter 5 in *COSPAR International Reference Atmosphere*, in press (1988).

#### PRESENTATIONS:

R. W. Smith, G. Hernandez, J. Conner, R. Viereck, G. J. Romick and C. S. Deehr. A large amplitude 6-hour tide in the MALT at Poker Flat. IAGA/IUGG Assembly, Vancouver, B. C., 1987

J. Conner, G. J. Romick, R. W. Smith and G. Hernandez. Fabry-Perot observations of winds near the mesopause height at Poker Flat, Alaska. American Geophysical Union, Fall Meeting, San Francisco, CA. (1987)

G. J. Romick, A. Alcock, J. Conner, C. S. Deehr, E. Hoch, R. W. Smith, R. Viereck and G. Hernandez. Very low airglow emission intensities in the auroral region - Spring 1987. American Geophysical Union, Fall Meeting, San Francisco, CA. (1987).

G. Hernandez, Interaction between the lower and upper atmosphere: Experimental evidence. Department of Atmospheric Sciences, University of Washington, Seattle, WA. (1988)

#### ABSTRACT OF OBJECTIVES AND ACCOMPLISHMENTS:

The main thrusts of this investigation have been the investigation of the dynamical and thermodynamical properties of the mesosphere, the lower and the upper thermosphere, as well as a supporting research program in spectroscopic instrumentation and techniques which has made possible to obtain the atmospheric measurements.

The instrumentation was moved to Poker Flat, Alaska because of the increasing light pollution in the Fairbanks area, where the instrument was previously located. The application of Telescience concepts to the automation of the instrumentation has made it possible to field the equipment to this unmanned site, yet communication via a telephone link makes it possible to interact with the instrument as easy as if the spectrometer was located in the room next door.



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The new freedom of operation has made it possible to begin an in-depth optical investigation of the dynamical and thermodynamical properties of the mesosphere and lower thermosphere in the polar regions. These studies use the near-infrared emissions of the OH molecule as tracers for the properties of the mesosphere and the visible emission of OI for the lower thermosphere. The use of the OH molecule near-infrared emissions has made it possible to study this nearly unknown region of the upper atmosphere even in the presence of auroral activity, since the OH emissions are specific to this region of the upper atmosphere. Thus far, the general behavior of the polar mesosphere has been determined and, in particular, we have been able to monitor a mesospheric event ( characterised by a decrease of mesospheric and thermospheric emissions by nearly one order of magnitude ) lasting from February 20 to April 3, 1987. During this period, the typical measured wind field has a variance much larger than its average value although, on a few occasions, the various wind components have varied in a coherent way indicating a dominating large scale motion.

The upper thermosphere measurements have been continued as the solar activity cycles goes from solar activity maximum to solar activity minimum. The data obtained thus far has been used to determine the control of the auroral zone upper thermosphere dynamics and thermodynamics by the interplanetary magnetic field, in particular the  $y$ -component. These results show the lowest magnetic latitude at which the classical symmetric two-cell convection is distorted, altering the ion drag forcing of the neutral thermosphere.

Investigation of high-luminosity spectrometers has given rise to the double-etalon modulator ( DEM ), which has a luminosity increase of nearly a factor of 100 over presently available multiple-beam spectrometers at an arbitrary resolving power. The DEM device, being a compensated device, has a luminosity $\times$ resolving-power that increases with increasing resolution. This property further shows the advantages of the DEM device, since the typical multiple-beam spectrometers have a constant luminosity $\times$ resolving-power product.

## Final Report

AFOSR 87-0174

### Investigations of the Dynamics and Thermodynamics of the Mesosphere and Upper Thermosphere at the Polar Regions

#### Abstract

The advances made in the investigations of the polar mesosphere and upper thermosphere under the auspices of AFOSR 87-0174 are presented. Briefly, the instrumentation at the Poker Flat field site has been made operational in teleautonomous mode. This application of Telescience principles has allowed long-wire operation of the multiple-beam spectrometer at the field site, and makes it possible to efficiently obtain further observations of the dynamics and thermodynamics of the upper thermosphere. These observations have been used to show the lowest latitude at which the  $y$ -component of the IMF distorts the classical two-cell convection cell in the upper thermosphere. The first simultaneous measurements of the dynamics and thermodynamics of the polar mesosphere show large fluctuations in the wind field and seem to be associated with temperature fluctuations. At this time, we were able to monitor a mesospheric event, characterized by a large decrease of the emission rate of the emissions from this region. A double-etalon modulator ( DEM ) has been theoretically developed and its properties have been experimentally confirmed. The DEM is a compensated device with nearly 100 times the luminosity of presently available spectrometers.

#### Introduction

The year that this grant was in effect has been very productive and has set the stage for further advances. The investigations carried under AFOSR sponsorship can be broadly divided into field and laboratory studies, which will be discussed below.

#### Field investigations

The field measurements are now made at Poker Flat, Alaska. The move to this remote station from the previous observing site ( at the 8<sup>th</sup> floor of the Geophysical

Institute of the University of Alaska ) was forced by the large increase in light pollution as both the University of Alaska and the City of Fairbanks increased the usage of high-pressure sodium lamps for outdoor illumination. Operation at the new site has been a success, mainly due to the application of Telescience concepts to the automation of the instrumentation. Such teleautonomous operation of the multiple-beam spectrometer has made it possible to inquire about the instrumental operation, environmental parameters at the site, directly operate the spectrometer, obtain data from the device, carry-out some limited repairs, change the operational parameters of autonomous operation, etc. via a ( telephone ) link. All this can be made from the Geophysical Institute ( about 35 miles away ) or from anywhere else a telephone line is available, yet the instrument appears to be in the room next door.

This form of operation is very efficient, since periodic checks take but a few minutes/week using the link, even though the instrumentation is located at a remote site with limited manpower and test instrumentation. The end result of teleautonomous operation has been the continuation of the upper thermosphere observations begun earlier and has facilitated the publication of results obtained to date ( Smith et al., 1988; Sica et al., 1988 ). In the latter publication, the data obtained in Alaska have been used to unambiguously determine and illustrate the control of the auroral zone dynamics and thermodynamics by the interplanetary magnetic field ( IMF ), in particular the  $y$ -component. These results show the lowest magnetic latitude observed at which the classical symmetric two-cell convection cell is distorted and altering the ion drag forcing of the neutral thermosphere.

Based on earlier AFOSR-funded investigation on new optical techniques of measurement, we have developed the only passive technique able to simultaneously measure the dynamics ( winds ) and thermodynamics ( temperatures ) of the mesosphere ( Hernandez and Smith, 1984 ). Measurements on the behavior and properties of the mesosphere are now routinely made at Poker Flat, and these new results have been presented at various meetings ( Smith et al., 1987; Conner et al., 1987; Romick et al., 1987; Hernandez, 1988 ). As described in those presentations, we have determined the typical behavior of this region of the atmosphere in the polar regions, but have also detected unexpected large fluctuations in the wind field which seem to be associated with temperature fluctuations. In particular, we were able to monitor a mesospheric event, lasting from February 20 through April 3 1987, with a signature given by the decrease of the mesospheric

emissions by nearly one order of magnitude. During this period, the typical measured wind has a variance much larger than the average value although, on a few occasions, the various wind components varied in a coherent way indicating a dominating large-scale motion.

### Laboratory Investigations

The laboratory studies encompass all other investigations not made at the field site in Poker Flat. Although the studies are diverse, they all have the common thread of improving the scientific results obtained by the ( present ) observations and/or making measurements heretofore not possible.

The theoretical development of the Double-Etalon Modulator ( DEM ) ( Hernandez, 1987 ) and its experimental confirmation ( Hernandez and McCormac, 1988 ) have shown the ability to increase the throughput of multiple-beam spectrometers by optical compensation. In other words the DEM device can be made nearly 100-times more luminous than the present Fabry-Perot spectrometers. This advance makes it possible to determine atmospheric emissions previously thought to be too faint to measure, as well as to increase the, light-limited, time-resolution of the features now observed. An important property of the DEM, being a compensated device, is that its luminosity $\times$ resolving-power product increases with resolving power. This is to be compared with the usual spectrometers, where the luminosity $\times$ resolving-power product is constant ( Hernandez, 1986 ), and showing that the DEM spectrometer gets better when the uncompensated devices start running out of steam. In addition, the DEM concept makes it possible to carry-out *simultaneous* measurements at many regions of the sky, without the burden of mechanically-driven mirrors.

A most useful property of the DEM is its inherent ability to do on-line optical pre-processing of the information previous to detection and, thus, reducing the amount of data that need be recorded to unambiguously determine the measurements. Other spatially sensitive spectroscopic techniques require the recording of each and every pixel of information, drowning the experiment under an enormous amount of raw data. This ability of the DEM to do on-line optical pre-processing is a leap forward in the field of spectroscopy.

The development of solid-state multiple-beam spectrometers is just commencing and should lead into very useful and varied spectroscopic instrumentation. At this time, the first step is to experimentally make an adjustment-free high-resolution spectrometer. An electro-optic etalon has been ordered, and its delivery has been delayed by the optical shop due to technical difficulties in doing the final wavefront polishing. Such a device directly impacts our field operations, because of the inherent reliability and lack of adjustments offered by these solid-state spectrometers. In addition to the reliability factor, these spectrometers are very compact, leading to the future small, reliable, adjustment-free field instrument. The availability of these spectrometers presents unique opportunities for novel applications in spectroscopy, now under investigation.

As part of the laboratory investigations small, but significant, improvements on the reliability and efficiency of the present instrumentation have also been made. One of these improvements has been the transfer from analog to digital control of the sensitive self-alignment feedback circuitry used with the present spectrometers. This improvement, in addition to providing the drift-free operation associated with digital techniques, makes it possible to have simpler control of the alignment of the instrumentation as part of the conversion to complete teleautonomous operation of the spectrometers.

Other studies, made under AFOSR sponsorship, include an in-depth review of the results, relating to the upper atmosphere, obtained by optical measurements. This review ( Hernandez and Killeen, 1988 ) has allowed us to place in perspective the present studies in the polar region, as well as to point the directions for some of the future investigations.

### Personnel

The persons associated with this grant have ranged from undergraduate students to established senior personnel. The results presented earlier would have been not possible were it not for the interest and work of these many people. The breadth of the program has made it possible for short ( undergraduate ) programs, graduate theses, and extending through long term studies not encompassed by the previous ( undergraduate and theses ) fixed term projects. Having a research program, where new things are being done, attracts young and bright people, who in turn push the program to the leading edge of the field, and this attracts more of them. Following is a list of the personnel directly associated during the term of grant AFOSR-87-0174:



James E. Schewe, Summer undergraduate program, University of Michigan.  
 J. Conner, Graduate student, University of Alaska.  
 A. Alcock, Graduate student, University of Alaska.  
 J. Minnow, Graduate student, University of Alaska.  
 Dr. R. Viereck, Graduate student, University of Alaska.  
 Dr. F. G. McCormac, Assistant Research Scientist, University of Michigan.  
 Dr. R. J. Sica, Research Assistant Professor, Utah State University.  
 Dr. R. W. Smith, Associate Professor, University of Alaska.  
 Dr. G. J. Romick, Professor Emeritus, University of Alaska.  
 Dr. R. G. Roble, Senior Scientist, National Center for Atmospheric Research.  
 Dr. G. Hernandez, Research Scientist, University of Michigan ( now Principal Research Scientist, University of Washington ).

### Publications and Presentations

- G. Hernandez, Afocal Coupled Etalons. DEM: a high-resolution double-etalon modulator spectrometer, *Appl. Opt.*, **26**, 4857-4869 (1987).
- G. Hernandez and F. G. McCormac, Afocal Coupled Etalons. Experimental confirmation of a high-resolution double-etalon modulator (DEM) spectrometer, *Appl. Opt.*, **27**, in press, (1988).
- G. Hernandez and T. L. Killeen, Optical measurements of winds and temperatures in the upper atmosphere. Chapter 5 in *COSPAR International Reference Atmosphere*, in press (1988).
- R. J. Sica, G. Hernandez, B. A. Emery, R. G. Roble, R. W. Smith, M. H. Rees and G. J. Romick. The control of auroral zone dynamics and thermodynamics by the interplanetary magnetic field dawn-dusk (*Y*) component. *J. Geophys. Res.*, **93**, submitted (1988).
- R. W. Smith, J. W. Meriwether, G. Hernandez, V. B. Wickwar and O. de la Beaujardiere. Global scale studies of thermospheric dynamics in the CEDAR program.

EOS, *Trans. Am. Geophys. Union*, **69**, in press, (1988).

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G. Hernandez, Interaction between the lower and upper atmosphere: Experimental evidence. Department of Atmospheric Sciences, University of Washington, Seattle, WA. (1988)

**Publications mentioned in the text, related to earlier AFOSR support.**

G. Hernandez, *Fabry-Perot Interferometers*, Cambridge University Press, Cambridge (1986)

Hernandez, G. and J. L. Smith, Mesospheric wind determination and the  $P_1(2)_c$ ,  $d$  lines of the  $X^2\Pi$  OH (8-3) band. *Geophys. Res. Lett.*, **11**, 534 - 537 (1984).